Using the Adaptive Cycles Framework to Conceptualize the Temporal Dimension of Teacher Learning

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Abstract: Attending to when and where teachers are with respect to change and learning—the temporal aspects of teacher learning—can yield more effective, timely, and responsive professional development (PD) efforts. Toward this end, we conceptualize phases of learning in a PD program, and how these phases are shaped by different resources and levels within teacher learning ecologies. Conceptually, we build on the Adaptive Cycles framework (Gunderson & Holling, 2002) and empirically, on video-based teacher conversation from a partnership with a PD-organization (PDO). We describe the learning of two school-based teams in the PD through the four phases of the Adaptive Cycles: problematization, reorganization, growth, and conservation. Findings show how the teams differed in their starting point, learning trajectories, and external resources invoked by participants. These findings strengthen our call for centering temporality and provide conceptual tools for doing so in research and practice, towards greater responsiveness to teacher learning ecologies.

לַכֹּל, זְמָן; וְעֵת לְכָל-חֵפֶץ, תַּחַת הַשָּׁמָיִם (קהלת ג' א')
To everything there is a season, and a time to every purpose under the heaven (Ecclesiastes 3:1)

Objective

For more than two decades now, sociocultural research on teacher learning highlighted its social and contextual nature, and as a result, portrayed quality PD as collaborative and situated in teachers' instructional contexts (Ball & Cohen, 1999; Horn & Garner, 2022; Kazemi & Hubbard, 2008). At the same time, empirical findings from such PD designs also point out several impediments to learning within teacher conversations (Borko et al., 2008; Horn et al., 2017; Vedder-Weiss et al., 2018), underscoring the need for ever more nuanced theories of teacher learning to inform teacher educators' responsive work (Cochran-Smith et al., 2014; Ehrenfeld, 2022; Horn & Garner, 2022; Opfer & Pedder, 2011; Stengel, in press). In this paper, we contribute this line of research by arguing that responsive PD efforts require a conceptualization of the temporal dimension of teacher learning.

We show why and how temporality matters by framing teacher learning as a *phased affair* with teachers open to various sorts of resources and interventions depending on where they are in their learning cycles. Theoretically, we take inspiration from sociocultural, ecological, and complexity theories and their guidance to (respectively) understand (1) teachers as agentic sensemakers; (2) within the context of their learning ecologies; (3) through phases of change and learning. Conceptually, we adapt and use the adaptive cycles framework (Gunderson & Holling, 2002). Empirically, we use data from Project SIGMa (Horn & Garner, 2022) to illustrate these temporal aspects of teacher learning. Project SIGMa was a research-practice partnership with a PD organization, and, as a central part of our joint work, we used video-based conversations to support secondary mathematics teacher teams in improving their practice. Here, we look at two school-based teams and ask: *How do different resources within teachers' learning ecologies interact in different phases of their learning?*

Theoretical and conceptual frameworks

This work is rooted in a sociocultural, ecological, and complexity perspectives on teaching and teacher learning. *Sociocultural research* on teacher learning informs our approach of privileging contexts and conversations, and positioning teachers as agentic learners and sensemakers (Horn & Garner, 2022; Lefstein & Snell, 2013). *Ecological theories* foreground the fact that learners are simultaneously involved in many settings and ask questions about the ways learning emerges from the interactions between these settings, as well as other resources and levels of teachers' learning ecologies (Bronfenbrenner, 1979; Cobb et al., 2003; Ehrenfeld, 2022). Finally, in line with ecological theories, a *complexity theory orientation* seeks to identify systems that interact towards the emergence of teacher professional learning (Cochran-Smith et al., 2014; Opfer & Pedder, 2011). In addition, models rooted in complexity theories also guide us to look at phases of change in ways that, we argue here, are useful for understanding teacher learning trajectories. An example is Gunderson and Holling's (2002) adaptive cycles framework.

The adaptive cycles framework

In traditional environmental ecology, processes of change within ecosystems (such as forests) were described as linear with two phases: growth towards an end point or climax, and conservation, the state the system would reach if not disturbed. However, in adaptive cycles, the climax, or the conservation phase, becomes a transition phase in a continuous cycle, proceeding through phases of release (later in this paper described as problematization), reorganization, and then again growth and conservation. In the forest example, the phase of release can be thought of as triggered by forest fires or drought. Then, in the reorganization phase, nutrients become available for new pioneer species to capture opportunities towards the following phase of growth. Finally, the framework also describes differences between the phases in terms of the level of resources in use, and the connectedness of components in the system (see Figure 1).

Figure 1
The four phases of the adaptive cycles
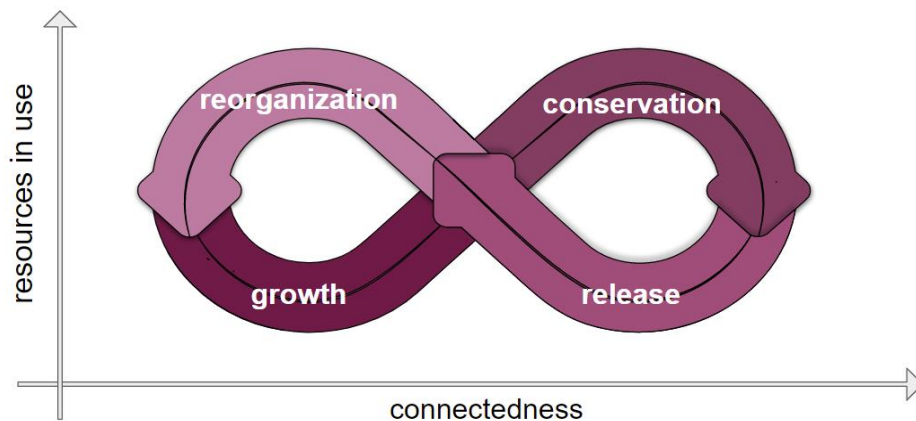
Note. The cycle reflects changes in two properties: (1) The y-axis represents accumulated resources in use (originally described by Gunderson and Holling as *potential*); (2) The x-axis represents connectedness of elements within the system. The behavior of loosely connected elements is largely influenced by external variability. The behavior of highly connected elements is mostly influenced by their inward relations, which strongly mediate external variability.

Adaptive cycles in the case of teacher learning

In the case of teacher PD, a focus on temporality helps us think about different phases in the teachers' learning trajectories and how they are supported by different resources (see Table 1).

Table 1
Four Phases of Adaptive Cycles in Forests and Teacher PD

Phase	Forest Analogy	Teacher PD
Growth	Competitive processes lead to a few species becoming dominant, potentially previously suppressed vegetation.	**Experimenting** with the new professional arrangement.
Conservation	Nutrient and biomass resources become bound with existing vegetation preventing others from utilizing them.	New practices are **consolidated,** and teachers are proficient with a new professional arrangement.
Release	Forest fires, drought, or intense pulses of grazing.	**Problematization** of institutional practices and teaching norms.
Reorganization	Nutrients become available for new pioneer species to capture opportunities.	**Navigating** tensions between institutional logics and teachers' pedagogical goals. Renewal, **planning**, and **recruitment** of new arrangements and practices

Growth is the longest and slowest phase and represents what Gunderson and Holling called *incremental learning*, where, in our case, teachers are experimenting with new teaching arrangements, adapting or rejecting practices according to their needs and sense of agency, until the arrangement becomes relatively stable. *Conservation* represents the phase when practices are consolidated, and teachers become more proficient with their professional arrangement. *Release* represents the *problematization* of current institutional logic and teaching practices, and often involve external agents as PD facilitators, or a new policy introduced to school (note that we renamed the release phase in the context of teacher learning as problematization). In the case of video-based PD, video-based reflection can also disrupt existing teaching and learning arrangements. Then, *reorganization* can represent navigating tensions between institutional logics and teachers' pedagogical goals, inherent conditions of teacher learning (Horn & Garner, 2022). Just as the reorganization phase in the forest is where nutrients become available for new pioneer species, teachers' reorganization phase is about renewal, planning, and recruitment of new arrangements and practices. Gunderson and Holling (2002) describe this phase as "the engine of variety and the generator of new experiments" (p. 74). At this point, transition to *growth* (experimenting with the new professional arrangements) and back to *conservation* may represent what Gunderson and Holling called *transformational learning*. Importantly, adaptive cycles also guide teacher educators' responsiveness to different phases of teacher learning. In the case of teacher learning, the x-axis in Figure 1 (and later with more elaboration in Figure 2) represents connectedness of resources and teaching arrangements within the system. Within the reorganization and growth phases, when resources and teaching arrangements are loosely connected, new invoked external resources are expected to be more salient in promoting change. In contrast, within the conservation and release phases, internal processes such as video-based reflection are more likely to be salient in promoting change. This distinction in central to our analysis and discussion of how different phases of teacher learning calls for different support.

Methods

Research context

This study is part of a larger research-practice partnership where the research team collaborated with a Professional Development Organization (PDO) to support the participating teachers' development of ambitious and equitable mathematics instruction. Through this partnership, we worked with teachers from six schools. All participating teachers had five or more years of experience and were affiliated with the PDO. Together, we co-developed a video-based formative feedback (VFF) intervention to provide teachers with timely information about their classroom instruction and help them make sense of problems of practice.

Data collection

During the 2017–2018 and 2018-2019 school years (Year 1 and Year 2 of our partnership), we worked with six school-based teacher teams, each ranging from two to five people. We visited and filmed teachers in each team one to six times over the course of the year. To film lessons, we used two cameras. Camera 1, a tablet camera on a robot tripod (Swivl), captured the whole class with a focus on the teachers' movements. Camera 1 also captured conversations from four student groups through four separate microphones placed at their tables. Camera 2, a point-of-view camera (GoPro), was mounted on the focal teacher's head, shoulder, or chest to approximate what they saw as they moved through the classroom interacting with students. In addition to these recordings, our classroom data included fieldnotes, lesson artifacts, photos of whiteboards and student work. The data also included fieldnotes about or recordings of conversations with the teachers before and after instruction, as well as texts and email exchanges with the teachers about the classroom activities. To film debrief conversations, we used the same wide-lens tablet camera and a recording of the researchers' laptop screen to document what teachers and researchers watched at any given time. In addition, debrief data included fieldnotes, photos of whiteboards when used, and fieldnotes about or recordings of informal conversations with the teachers before and after the formal debrief. All 32 debrief conversations were initially transcribed by an external transcription service and then finalized by Project SIGMa team members.

Focal cases

Within this larger group of well-supported and experienced secondary math teachers, we focus here on the Rees Middle-School team (Ezio and Veronica) and the Noether High-School team (Brad, Marisa, Abigail, and Greg). These two school-based teams had a similar leading concern, which remained relatively stable across our partnership. Both teams had the explicit goal of promoting student collaboration. This goal typically included a focus on teaching conceptual math content and supporting social inclusion. Notwithstanding their similarities, the two teams perceived their institutional contexts in significantly different ways. At Rees, tensions between the

teachers' personal commitments and school practices were significantly more contradictory. In contrast, at Noether, between Year 1 and Year 2 of our partnership, one focal teacher (Brad) was appointed as department chair. This shift implied that he had greater agency around issues like curriculum design and even purchasing classroom furniture to better support student collaboration. Another difference between the two teams was the length of our partnership. By the end of Year 1, one of the two teachers from Rees moved schools and our partnership ended. However, our work with Noether continued to Year 2, with a one-time Member Check visit in Year 3. Year 1 with the Rees team included three VFF cycles. Year 1 and Year 2 with the Noether team included six VFF cycles. Secondary data include interviews with the participating teachers.

Data analysis

The overarching goal of this data analysis was to understand the teachers' learning was in different phases of the PD, how their "phasing" impacted what resources they are bringing to bear, and what they accounted for because of where they are. We looked at learning trajectories across all meetings we had and described the teams' learning at the PD through the lens of the adaptive cycles. For each of the phases of *problematization*, *reorganization*, *growth*, and *conservation*, we asked whether and where do we recognize conversations that are associated with this phase. First, for the phase of problematization, we searched for and analyzed instances where teachers problematize either institutional practices and norms, or aspects of their own instruction. Second, for reorganization, we focused on instances where teachers discussed planning and recruitment of new ideas, including the tensions between institutional context and their own pedagogical goals. Third, for growth, we focused on instances where teachers tried out relatively new ideas and professional arrangements (in and out of classroom.) Finally, for the phase of conservation, we focused on evidence that teachers became proficient with new professional arrangements, to the extent that these arrangements were consolidated and stable within teachers' routine practices.

Notably, we quickly learned that instances that represent the four phases were usually mixed across the data, that many episodes can be seen as representing multiple phases, and that phases were never really "done" but more or less salient at different points of the conversations. In other words, while these categories are analytically distinct, real life is messier. We tried to consider this messiness in our analysis and be explicit about it. This nuance in and of itself led to some interesting findings. For example, when the Rees team mostly coordinated resources in light of institutional contexts, we considered it *reorganization*. When the Rees team mostly tried out these new resources, we considered it *growth*. However, we noticed that while the main focus of the formal video-based conversations became the growth, our informal conversations with the teachers were still a space for teachers' sensemaking about their reorganization, highlighting how formal and informal dimensions of the PD were interrelated.

Finally, we explored the guidance provided by adaptive cycles to consider the influence of external variability on different phases of learning. Adaptive cycles suggests that within the reorganization and growth phases, invoked external resources will be more salient. In contrast, in the conservation and release/ problematization phases, internal processes such as video-based reflection will be more salient. The temporal analysis is reported in the following section.

Findings

In this section, we describe our partnership with the two teams through the lens of the four phases. First, we show that our work with the Rees team centered on the *reorganization* and *growth* phases. Then, in contrast to Rees, we briefly describe how our work with the Noether team can be seen as a *full adaptive cycle* across all four phases. We conclude by considering implications to designers' and facilitators' responsiveness to teacher learning by using the lens of temporality.

Rees: The PD focused on the reorganization and growth phases

Several years before our partnership began, Ezio and Veronica moved to Rees High-school from the same previous school. Veronica moved first. She was displaced from their old school as the youngest teacher in the department, with less than 5 years of teaching experience at the time. Ezio joined her shortly after, with more than 15 years of experience. When they re-joined forces at Rees, Ezio and Veronica had a strong collegial relationship and collaborated as much as their schedules allowed. This collaboration strengthened when they joined the PDO as a team, which bought them an official shared planning time during their school day. As a team, Ezio and Veronica shared two main goals. First, they wanted to change their lessons to support more student collaboration. In an interview in Fall 2017, they described supporting student collaboration as a topic they tried to grow the most that year. Ezio described not having a lot of experience with student small groups and mentioned he was working on leading students to the answers instead of simply giving answers. Veronica described groupwork as being

"outside her comfort zone," and yet she was willing to take "big risks" and try new practices in her classroom. Second, Ezio and Veronica felt a commitment to work towards making their school more equitable. Both teachers were frustrated by the distribution of resources within school, which they felt was favoring affluent families. These families were either newcomers to the school's gentrified neighborhood, or students who were recruited to school's magnet program from other neighborhoods.

Problematization of school routines happened before the PD

Using the terminology of the adaptive cycles, the phase of *release* — the *problematization* of their school routines and of their own teaching — mostly happened before our intervention. Specifically, Ezio and Veronica had grown concerned about the unofficial tracking in their department. For them, tracking was not just about differentiating levels of math classrooms but extended to other activities (such as electives) and created what Ezio called a "sharp divide" between different groups of students. In other words, Ezio and Veronica started our partnership with relatively clear articulations of issues that bothered them in their classrooms as well as in their school. The phase of *reorganization* represents the generating of ideas to address these problems, navigating tensions between institutional practices and their personal commitments.

Reorganization and growth phases

The phase of *growth* involves experimenting with new ideas and instructional practices. Our work with Rees across three VFFs focused on these two phases. Rees VFF 1 illustrated their preliminary reasoning with regards to groupwork facilitation, and the recruitment of ideas towards supporting more equitable student collaboration (i.e., *reorganization* phase). For instance, in Rees VFF 1, Ezio and Veronica made a strong connection between their grouping strategies and their institutional concerns about stigmatizing groups of students. When it came to grouping strategies, they noticed that purposeful grouping amplified the consequences of tracking in the shape of labeling kids as "dumb" or "awesome" — even if teachers did not explicitly state their grouping scheme — while random grouping disrupted it. Then, the following two VFFs were mostly focused on experimenting with and consolidating instructional practices such as random grouping, re-grouping, and rotating groups (i.e., *growth* phase). For example, Veronica started incorporating the aforementioned random grouping into her teaching routine. In this case (Rees VFF 2), Veronica implemented it by the book, with limited flexibility and discretionary judgment. Trying out these new practices constituted experimenting. The debrief offered her an opportunity to hone her flexibility and consider overriding the randomness to attend to the specific teaching situation, which allowed her to consolidate some of her understandings of her experiment. For another example (Rees VFF 3), Ezio incorporated the instructional practices of rotating-groups, another experiment. This new practice introduced to Ezio and Veronica by their PDO coach. The debrief offered teachers several opportunities to consolidate the practice. The idea was that when groups were rotating, they left (by design) their whiteboard scribes to the following groups to reflect on. However, in watching the clips of his classroom, Ezio realized that when he addressed the groups, he talked to the students as if they wrote the scribes next to them, which resulted in some type of miscommunication.

Notwithstanding the analytic distinction between the two phases, the reorganization challenges in light of the school context were never fully resolved. Even though the formal video-based conversations shifted to focus on experimenting with new instructional practices, Ezio and Veronica continued to mention their concerns about school in interviews and informal conversations, and our team used these opportunities to support them on this end. For example, one of our team members described to Ezio Rochelle Gutiérrez's argument of why teachers need political knowledge and creative insubordination (Gutiérrez, 2016). This example calls attention to seeing the VFF cycle — and PD in general — as an activity that happened both on the formal "front stage" (the video-based conversation) and on the informal "backstage" (Goffman, 1959).

Conservation: No evidence for a stable phase

Throughout our partnership, Ezio and Veronica demonstrated instructional growth, however, we cannot describe these new instructional arrangements as stable. Using the terminology of the adaptive cycles, Ezio and Veronica did not reach the phase of *conservation* with their new practices. Rather, our work with the Rees team was centered on reorganization and growth. In contrast, the case of the Noether team illustrates a full adaptive cycle.

Noether: The PD entailed full adaptive cycle toward stable changes

The Noether team included four teachers: Brad, Marisa, Greg, and Abigail. The four teachers had different backgrounds and years of experience. For Brad, Noether was his first teaching job. He was there for over five years, and at the end of the first year of our partnership, he was appointed department chair. Marisa was new to the school and was Brad's collaborative planning partner. This section mostly focuses on them as a subgroup

within the Noether team. Abigail arrived at Noether the same year as Brad, after teaching at another school for two years. She had a close relationship with Brad and Greg, who both described her as someone who helped them become better teachers. Greg was the most experienced teacher on the team with more than 20 years experience, all at Noether. Brad himself was inspired by Greg's commitments, as a veteran teacher, to shift his teaching and focus more on students' thinking and discussions. In sum, the team was supportive and collaborative, committed to improvement, and included a variety of backgrounds and experiences.

Problematization: Seeing where instruction falls short through video-based reflection
Notwithstanding the team's collaborative and committed nature, the Noether team did not show signs of arriving at our partnership with a sense of urgency, neither with regards to their institution nor their teaching. in contrast to the Rees team, *problematization* of some aspects of their instruction, and of institutional norms, emerged within the PD as a result of the video-based reflection. The three VFFs in Noether Year 1 often included problematization of the teachers' practices. By problematization in this case, we mean that we discussed central aspects of instruction aligned with the teachers' stated goals, and yet, were still not recognized by them as possible avenues of growth in their teaching. These aspects included, for example, refraining from providing students with answers and instead directing students to each other as resources of mathematical knowledge.

Reorganization: Planning new teaching arrangements
Toward the end of Year 1, it became evident that Marisa and Brad were not only reflecting on and problematizing their practice, but also considering ways to *reorganize* their teaching arrangements. Noether VFF 3 signaled this shift. After watching a video clip of Brad's groupwork facilitation, the research team pointed out the gap and possibility of further directing students' questions to each other within the group. Marisa then invoked her experiences teaching a problem-based curriculum in her previous school to suggest that the constraints of supporting student collaboration are stemming from the culture of their classrooms and school. In later interviews, we found further evidence that these discussions pushed Brad and Marisa to reorganize their classroom and units. Indeed, in the following year, Brad and Marisa used their common planning time to restructure their curriculum and to experiment with new lesson structures.

Growth: Experimenting with groupwork
During Year 2, Brad and Marisa restructured their classrooms to have students work in small groups daily over a five-week unit on statistics. This was the context for Noether VFF 6. At this point, Brad had become department chair and therefore had greater agency in curriculum design. Brad and Marisa took advantage of the new design to "dive in full" into groupwork experimentation in the way Marisa pushed to in the previous year. Brad's classroom design and interaction with student groups in Noether VFF 6 included changes that echoed Marisa's previous experiences with the problem-based curriculum that she invoked frequently. Their experiments with these ideas (e.g., directing students to each other when asking questions) represented a phase of *growth* towards the following phase of consolidating the new arrangements into relatively stable practices

Conservation: New teaching arrangements consolidated into a stable practice
Until now, we described how Brad and Marisa's learning trajectory spanned across the three phases of problematization, reorganization, and growth. Our argument in this last section is that Year 3 illustrated a full adaptive cycle towards a new stable practice. The new stable practices were supported by a variety of resources and levels in the teachers' learning ecology: VFF video resources, together with their shared analysis, external resources like curricula and conferences, and institutional resources such as Brad becoming the department chair. All of these supported Brad and Marisa in the adoption of new structures and practices around the notion of groupwork. In February 2020 of Year 3, our team members visited Brad's classroom for a Member Check. (At this point, Marisa had moved to a new school for family reasons.) Coincidentally, they arrived a day after Brad received new group tables to replace his individual desks with obstructive arm trays that made groupwork difficult. He had completely built the lessons they observed around student collaboration, and our team members noted in their fieldnotes that students seemed used to it (which Brad confirmed in the interview). Importantly, our team also noticed several instructional moves we had discussed during past VFFs: (1) quiet circulation in the classroom listening to groups; (2) asking what students were talking about; (3) directing students to each other rather than giving them answers; (4) using student roles. In the interview after the Member Check observations, Brad recalled this learning process:

> I remember you guys came and observed somebody and it was like we had been very new into doing groupwork. [...] And I just felt like the kids needed to talk more and needed to work together more and that I just needed to change things up [...] So, I did all year group work, fall

to spring and then Geometry. I only started last spring. So they're used to working in groups […] highest level kids that are used to just being A students and don't need the other three end up valuing group work by the end of the year. So... so I've just dove in full on to having all my classes work in groups.

Overall, there was a lot of evidence in Brad's classrooms that he has developed more strategies, structures, and awareness about setting up and supporting effective groupwork. Even more, Brad recalled how these arrangements started with *problematization*/*release*, when he "remember you guys came and observed… I just needed to change things up." They then shifted to *reorganization* and *experimentations*, during which he and the kids got used to work in groups, and side by side with their frustrations, students are seeing the affordances. Eventually they seemed to arrive at a stable phase, which we argue is a new *conservation* phase.

Summary and comparison of the two cases

In this analysis we used temporality as an analytic tool to view teacher learning as a phased affair, with teachers open to different support depending on where they are in the adaptive cycles (see x-axis in Figure 2). Ezio and Veronica from the Rees High School were mainly concerned with establishing new professional arrangements, experimenting with them, and coordinating their work with school norms and policies. In other words, our work with them centered on the reorganization and growth phases (see green line in Figure 2). In addition, there is evidence that at the end of our partnership their new teaching arrangements did not yet stabilize and reached another phase of conservation. In contrast to Rees, we described our work with the teachers at Noether as spanning almost across all four phases (see blue line in Figure 2). For Noether, we used the metaphor of release to describe the phase of acknowledging and reflecting on the gap between the teachers' pedagogical goals, and the ways their teaching often played out in the classroom and fell short with regards to student learning. Then, transitions from problematization to reorganization represents navigating tensions between institutional norms and teachers' pedagogical goals towards renewal. A main institutional resource in this phase was Brad becoming the department chair. At this point, the transition from reorganization to growth included experiments with the new visions of collaborative learning, towards a well-established new arrangement we found in a Member Check in Year 3, that can be described as nearing conservation.

Figure 2
Revisiting the adaptive cycles in the cases of Rees and Noether
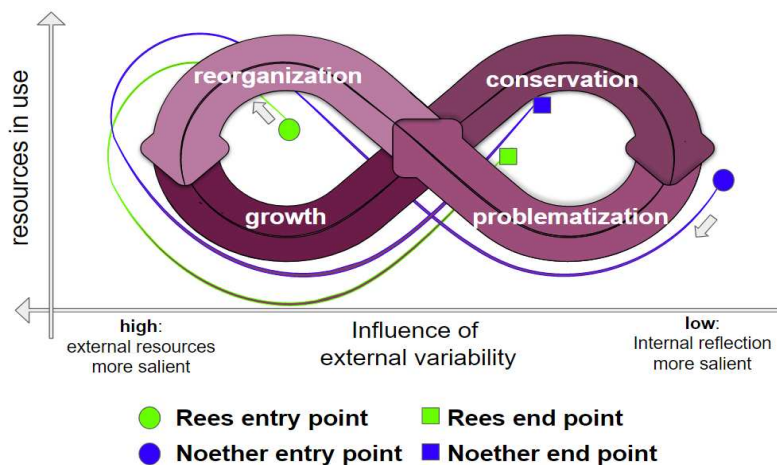
Discussion: Responsiveness to different phases of teacher learning

Responsiveness to different phases of teacher learning calls for different support. As a general guidance, this example suggested that in the conservation and problematization phases, internal reflection has more potential to promote change. This was particularly evident in the case of Noether VFFs in Year 1, where problematization mainly stemmed from reflection on video representations of teaching. In addition, these examples suggest that in the reorganization and growth phases, acknowledging and providing a variety of external resources has more potential to promote change. Within the reorganization phase, the focus should be on reconciling these resources with school context, and in the growth phases on experimenting and consolidating them into practice.

Temporal analysis and comparison between the Rees and Noether VFF cycles resulted in several more insights. First, while the phases in Figure 2 are analytically distinct, in real life, they are interrelated. For example, while Ezio and Veronica were experimenting in the growth phase, they kept making sense of their school contexts and coordinating external resources (reorganization phase). Relatedly, this analysis also highlighted how formal and informal dimensions of the VFF cycles were interrelated, as when the informal conversations with Ezio and Veronica provided additional opportunities to provide resources and support. This insight extends the meaning of responsiveness in PD, from facilitation of the formal video-based conversation to the ongoing formal and informal communication and relationship building.

As we work towards more nuanced theories of teacher learning, we call to centering responsivity for teacher learning trajectories and their temporality in the sense of time that Erickson (2004) referred to as *kairos*, which in modern Greek means *opportunity*, or "a brief strip of the right time." (Erickson, 2004, p. 7). It is the qualitative aspect of time as humanly experiences. It is not simply duration (as often time is discussed in literature of teacher learning) or the sequential *chronos* from point A to point B, but rather a lens for supporting teachers with responsibility and attention (Stengel, in press), providing them the right resources at the right moment.

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